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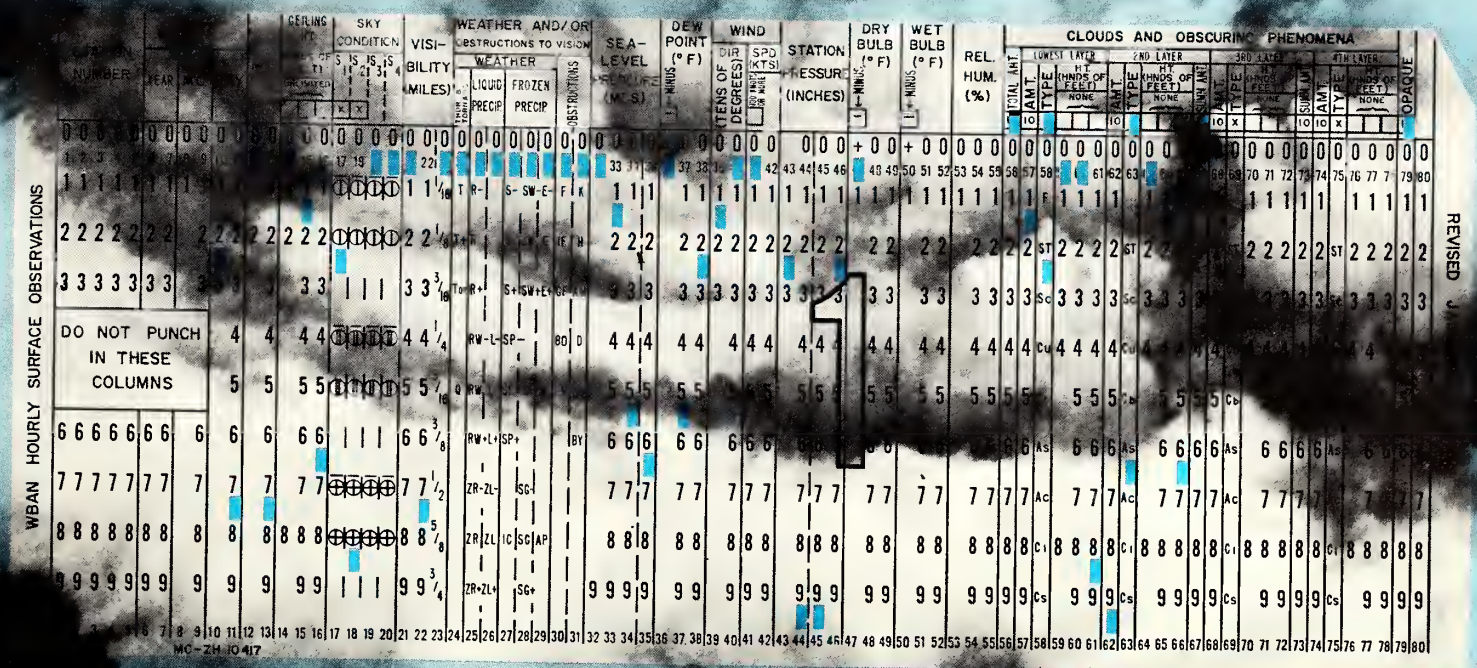
THE NATIONAL WEATHER RECORDS CENTER

ASHEVILLE, N. C.

PENNSYLVANIA STATE UNIVERSITY
AUG 26 1967
DOCUMENTS COLLECTION



U.S. DEPARTMENT OF COMMERCE / ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE
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ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
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ENVIRONMENTAL DATA SERVICE
Helmut E. Landsberg, Director

JANUARY 1967

PREFACE

This pamphlet describes the functions, capabilities and scope of the National Weather Records Center (NWRC) located at Asheville, North Carolina. This unit is an arm of the Environmental Data Service (EDS) of the Environmental Science Services Administration (ESSA). It is the largest of several environmental data banks and data processing facilities in EDS At the same location is the National Geophysical Data Center with two branches, Seismological and Geodetic. These collect, file and process world-wide seismological and geodetic data. The third principal center of the Environmental Data Service is the Aeronomy and Space Data Center located at Boulder, Colorado, where the high atmosphere, radio propagation, and space data are held for users.

The National Weather Records Center closely cooperates with the U.S. Naval Weather Service and with the Data Processing Division of the Environmental Technical Applications Center, Air Weather Service, U.S. Air Force. As the central climatological data facility of ESSA, NWRC collects and processes climatological data for civilian agencies. Under a reimbursable arrangement with the U.S. Navy, it performs the Navy's climatological data collection and processing. For the Air Force, processing of climatological data is accomplished by the Data Processing Division of the Air Weather Service, which shares the Federal Building in Asheville with the NWRC and the National Geophysical Data Center. Close coordination exists between these activities.

This booklet is an effort to provide information to those who can benefit from analyses of weather data. The reader is given an insight into the benefits climatological information can provide for his home, his profession, his business and his community. A brief history, a description of the Center, and the services provided are included. Section VI discusses special services, and Section VII gives information on "Requesting Climatological Services." The hurried reader may wish to check these last two sections first, to determine whether products or services are already available that will satisfy his requirements. If they are not, the final section tells him how to "place an order."

"The National Weather Records Center" was written at Asheville by William P. Nash, with the assistance of other staff members of the NWRC and EDS. Among many sources of information available to Mr. Nash was "Climatology at Work," edited by Dr. Gerald L. Barger and John C. Nyhan in 1960. Many others contribute to the final product.

H. E. Landsberg, Director
Environmental Data Service

CONTENTS

Preface ---------- i

SECTION I. INTRODUCTION ---------- iii

SECTION II. HISTORICAL BACKGROUND- 1
- Climatology prior to World War II ----- 1
- Climatology's Growth during the War --- 2
- Advances since World War II ---------- 2

SECTION III. THE PRESENT ORGANIZATION ---------- 3
- Primary Functions ---------- 3
- Other Functions ---------- 3
- Professional Staff ---------- 4
- Agency Affiliations ---------- 4

SECTION IV. PHYSICAL RESOURCES ---- 6
- The Information Bank ---------- 6
- Machines ---------- 16

SECTION V. CLIMATOLOGICAL PUBLICATIONS ---------- 17
- Subscription Publications ---------- 17
- Unscheduled Publications ---------- 20

SECTION VI. SPECIAL SERVICES -------- 22
- Data Tabulations ---------- 22
- Climatological Investigations ---------- 25
- Reproduction of Climatological Data --- 28

SECTION VII. REQUESTING CLIMATOLOGICAL SERVICES ---------- 30
- If an Agency of the Department of Defense 30
- If a Non-Military Federal Agency ------ 30
- If a Non-Federal Agency, A Private Organization or Company, or an Individual -- 30
- Job Requests and their Specifications ---- 31

Conclusion ---- 33 List of Illustrations ---- 33

INTRODUCTION

The National Weather Records Center (NWRC) is the largest operating division of the Environmental Data Service, which is a major component of the Department of Commerce's Environmental Science Services Administration (ESSA). Weather records are collected, quality controlled, summarized, published and distributed by the NWRC. Basic records are archived, microfilmed and retrieved as needed by users. Special climatological services are performed for other government agencies, universities, corporations and any individual requesting them. These services are described in Section VI. Discussions of information resources, facilities and talents within the organization to satisfy requirements for climatological information are included.

The NWRC is physically housed in the Federal Building, Asheville, North Carolina. (figure 1). Almost 3,000 people visit the organization each year. You have an open invitation to visit us at any time.

FIGURE 1

Research Aircraft gather atmospheric data,
much of which is later archived at the
National Weather Records Center

HISTORICAL BACKGROUND

The National Weather Records Center came into being in late 1951 as an outgrowth of the New Orleans Tabulation Unit (NOTU). NOTU was established during the early stages of the second World War with the primary responsibility of conducting climatological investigations requested by the Armed Forces.

CLIMATOLOGY PRIOR TO WORLD WAR II

Modern climatology owes much to Thomas Jefferson, who early recognized a need for systematically recording the climate of the United States. In view of his prominence and lifelong enthusiasm for climatology, it is difficult to understand why nearly a full century elapsed between publication of his first climatological notes and the emergence of a firm framework to survey this vital natural resource.

There was no organized system of taking weather observations until the 19th Century, when successive advances were made by agencies of the Federal Government. The U.S. Weather Bureau, created in 1870 under the U.S. Signal Service (later Signal Corps), was made a civilian agency and transferred to the Department of Agriculture in 1891. The Act of Congress effecting this change charged the Weather Bureau, among other duties, with " . . . the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States . . . ." (See note below.)

"The Cooperative Weather Observer," Key to Meteorological Records Documentation No. 1.11, gives an interesting and a far more complete account of the birth and growth of the Nation's weather service, including the historically prominent Americans who were pioneer weather observers. It is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.

The new civilian Weather Bureau inherited an operating Climatological Service, although small compared to that which exists today. Government-operated stations numbered about 180, but, as today, the bulk of data used to establish the climate came from public-minded citizens who volunteered to record temperature extremes and daily amounts of precipitation. There were more than 2,000 of these cooperative stations at the time, and the number has increased to about 12,000. These surface observations from land stations grew in number, as did the collection of ocean and upper air observations. By the late 1920's data holdings in Weather Bureau files had reached "staggering" proportions.

Although the punched card method of data processing was born in the United States, its application to climatological data had its beginning in Europe. Testing of machine techniques in summarizing climatological data in the United States had to await the work projects of the Civil Works Administration and its successor, the Works Progress Administration (WPA), during the depression years. A much-needed marine atlas was completed in 1936. Employing machine methods, this represented (as of that time) the greatest achievement in the United States in summarizing large quantities of climatological data.

Another important accomplishment prior to World War II was the compilation and analysis of surface and upper air observations made at about 400 airways weather stations in the United States. These data, covering the period 1928 to 1941, were summarized and published. This work opened the "floodgates" for numerous useful applications by the airlines as well as by the government.

HISTORICAL BACKGROUND

CLIMATOLOGY'S GROWTH DURING THE WAR

Data summarization projects such as those just described demonstrated the value of applying weather history to today's and tomorrow's operational problems. The attack on Pearl Harbor came about this time, and weather statistics and their interpretation became vitally important overnight. Many weather forecasts leaned heavily on probabilities as determined from weather observations taken over a long span of years. Applied climatology got a real "shot in the arm." The value of weather history in strategic and tactical planning soon became apparent, and demands for climatological studies to meet military requirements grew by leaps and bounds. Answers in many cases would have been "too little and too late" were it not for the experience in machine processing gained through the WPA projects.

Advances in climatology during the war, briefly, were:

- **RECOGNITION** of climatology as a significant factor in civil and military planning
- **STANDARDIZATION** of methods of observing and recording weather elements by the Weather Bureau, the Army Air Forces, and the Navy
- **MACHINE PROCESSING** of punched cards as an efficient method of handling large quantities of data
- **CENTRALIZATION** of collection and storage of weather records
- **GLOBAL PROCUREMENT** of weather data

ADVANCES SINCE WORLD WAR II

Climatology clearly was here to stay and to grow in the post-war era. Typical of the questions posed by planners of new air bases, for example, were:

- How should the runways be oriented?
- Which runway should be equipped for instrument takeoffs and landings?
- Will snow removal equipment be needed?
- What types of clothing will aircraft mechanics working outside require?
- Will offices and living quarters need to be air-conditioned?

In 1948, quality control was expanded in the U.S. records collection program. Air Force and Navy checking operations were centralized, while the Weather Bureau established regional processing units to check, summarize, and publish data. Machine techniques were applied at this time to the problem of data quality, eliminating many of the man-hours required previously to check observations for consistency and reasonableness.

Concurrent with growing military requirements, industrialists, agriculturists, researchers and others were asking for more and more climatological information to assist in planning in such areas of interest as housing, marketing, shipping, aviation, air conditioning, flood control, manufacturing, vacationing, and many others. As job requests grew in number and complexity, data processing equipment, of necessity, turned slowly toward the new technology of electronic automation.

The National Weather Records Center was established in 1951. The Weather Bureau's regional processing units were consolidated at the NWRC during late 1962 and early 1963 as a measure to increase the economy, efficiency, and effectiveness of the overall program. With the advent of larger and more powerful electronic computers, quality control, summarization, and publication of climatological information could be done at less cost in a single location.

THE PRESENT ORGANIZATION

The "real" purpose of the National Weather Records Center is to make climatological information available in a suitable form for use in making decisions involving strategy, time, and money. The raw material for this purpose consists of the weather observations taken over a period of years by (1) the Weather Bureau and its cooperators, (2) the Air Weather Service of the Air Force, (3) the Naval Weather Service, and (4) foreign meteorological services. These data are processed by the Center and then made available for use in agriculture, aviation, commerce, construction, industry, navigation, public health, research, space exploration, etc.

PRIMARY FUNCTIONS

The NWRC's primary functions are to:

- **COLLECT** the observational records of the Weather Bureau, the military weather services, and cooperative observers on land, on sea, in the air, and in the aerospace.
- **QUALITY CONTROL** these data with machine and manual edits, except Air Force observations. (The Air Force edits its own observations.)
- **SUMMARIZE** these data into useful statistical parameters, such as means, extremes, departures from normal, etc.
- **PUBLISH,** on a timely basis, both the raw data and summarizations of the data.
- **DISTRIBUTE** the publications to subscribers and all others requesting them.
- **ARCHIVE** the original records and such derived forms of the data contained in them as may be appropriate.
- **MAINTAIN A REPOSITORY** of climatological data.
- **MICROFILM** original and derived records for compact permanent retention as appropriate.
- **RETRIEVE** the records from the archives when needed
- **REPRODUCE** the records to fill requests.

OTHER FUNCTIONS

Other functions of the NWRC include:

- **COLLECT OBSERVATIONS** and **REPRODUCE** in microphotographic form for subscribers as a daily listing of data for the entire Northern Hemisphere.
- **PREPARE** for publication daily synoptic **CHARTS** of the surface and 500-millibar pressure levels for the entire Northern Hemisphere.
- **PUBLISH,** under the auspices of the World Meteorological Organization, monthly and annual **CLIMATIC SUMMARIES** for the West Indies and Caribbean and, in a separate publication, monthly climatic summaries for the World.
- **PROCESS** back-log records for **LONG-TERM CLIMATIC SUMMARIES.**
- **FOSTER HIGH QUALITY IN OBSERVATIONS** among Weather Bureau and cooperative observers by advising the station observational personnel and the Regional Headquarters of errors found in observations and by furnishing interpretations of observational instructions when necessary.
- **UPDATE PROCEDURES AND MACHINE TECHNIQUES** as necessary to insure the highest quality possible in climatological records.
- **CONDUCT RESEARCH AND DEVELOPMENT** as assigned or approved by the Environmental Data Service.

PROFESSIONAL STAFF

The NWRC has the scientific and technical staff to make any type of climatological investigation, provided, of course, that sufficient data of the kinds needed are available for the geographical area of concern. Academic achievements among the professional staff extend to the doctorate and post-doctorate levels. Most of the employees have had many years of experience in climatology.

Highly-experienced observers check records; card and tape punch operators convert observational records into media acceptable as input by the computer; digital systems programmers converse with the computer in its "language"; photographers, printers, and others perform specialized tasks. The NWRC has approximately 380 employees in the following occupational skills:

- Clerical and Other Support Personnel
- Digital Computer Systems Operators
- Digital Computer Systems Programmers
- Draftsmen and Illustrators
- Electric Accounting Machine Operators
- Electric Accounting Machine Project Planners
- Electronic Technicians
- Geographers
- Key Punch Machine Operators
- Mathematicians
- Meteorologists (Climatologists), some of which are also Statisticians
- Meteorological Technicians
- Office Machine Operators
- Photographers and Photographic Equipment Specialists
- Printers

AGENCY AFFILIATIONS

Although located at Asheville, North Carolina, the National Weather Records Center functions as the principal data processor of the Environmental Data Service in Washington, D.C. The NWRC has direct responsibility for its own administrative actions and for a large percentage of the Environmental Data Service's total operating program.

The NWRC houses and provides administrative support to ESSA's National Geophysical Data Center, consisting of the Seismological Data Branch and the Geodetic Data Branch.

The Seismological Data Branch collects, stores, indexes and provides very exact film and paper reproductions of seismograms for distribution to seismologists and other scientists participating in seismic research. The seismograms are produced at stations of the World-Wide Network of Standardized Seismographs.

The Geodetic Data Branch collects, stores, inventories, and distributes published geodetic data and information. Among the items are geographic positions of latitude, longitude and plane coordinates; azimuth data; and descriptions of locations. Other data include elevations and descriptions of bench marks; diagrams in the form of maps at various scales showing locations of control stations; and supporting indexes.

The Air Force and the Navy share climatological data resources with the NWRC, but maintain units of their own in the common facility at Asheville. While the military units cooperate closely with the civilian ones, they are organizational entities sep-

arate from the NWRC. Each of the three has a different command channel.

The Air Weather Service of the Air Force has a staff of almost 200 people (in addition to those of the NWRC), including computer programmers and operators. Designated the Data Processing Division, the Air Weather Service Unit is an operating arm of the Environmental Technical Applications Center (ETAC), located in Washington, D.C. It checks observations from the global network of the Air Weather Service and provides climatological support to the Air Force and the Army.

The Navy unit at Asheville is much smaller than that of the Air Force. The NWRC fulfills most of the Navy's climatological requirements on a reimbursable basis; liaison and coordination, therefore, are the primary functions of the local office of the Navy Representative.

The United States is a member nation of the World Meteorological Organization (WMO), a specialized agency of the United Nations. International cooperation on meteorological and climatological matters is promoted through the various technical commissions of the WMO. The NWRC contributes to the international efforts of the United States through working groups of the technical commissions, especially Maritime Meteorology and Climatology. An example of effective cooperation through the WMO is the international exchange and standard summarization of observations from ships at sea.

Only through world-wide, international effort can the nature of the atmosphere be understood and its future behavior predicted. Under the impetus of resolutions of the United Nations, the World Meteorological Organization has been developing plans for a proposed system for a "World Weather Watch." Three principal centers are proposed: Moscow, Washington and Melbourne. The Washington center began functioning in January of 1965. It combines the U.S. Weather Bureau's numerical prediction and satellite facilities with the National Weather Records Center's data storage and recall capabilities.

The NWRC houses the World Data Center A (WDC–A) for Meteorology and Nuclear Radiation, under the sponsorship of the National Academy of Sciences. WDC–A functioned during both the International Geophysical Year (1957–58) and the subsequent International Geophysical Cooperation 1959 as the repository for data in these disciplines. As in subsequent international data collection periods (as the International Year of the Quiet Sun 1964), these data were archived, cataloged, and made available on a loan or "at cost" basis to any researcher throughout the World. Activities of the WDC–A have been expanded recently to include the publication of data obtained from meteorological rocket soundings made in the United States, Canada, and Great Britain. Radiosonde (balloon) observations made nearest the time of rocket firing are also contained in the publication.

PHYSICAL RESOURCES

The National Weather Records Center occupies a large part of the Asheville Federal Building, which covers a city block and is four stories high. Housed in this building, in addition to personnel and the usual office facilities, are a variety of complex processing machines and a vast repository of records. This repository is referred to below as "The Information Bank."

THE INFORMATION BANK

The Information Bank in the NWRC consists of a collection of original manuscript observational forms and autographic traces of various meteorological elements; records reduced to microfilm, magnetic tape, and punched card forms; radar and satellite films; climatological publications; and unpublished tabulations and analyses. Summarized below are approximate present data holdings and annual rates of data accessions:

FORM OF DATA	ON HAND (May 1966)	ANNUAL ACCESSION RATE
Original manuscripts and autographic traces (sheets)	62,000,000	2,700,000
Microfilms of original manuscripts and autographic traces (100-foot reels)	60,000	3,000
Punched cards including microfilmed card images	490,000,000	25,000,000
Magnetic tapes (2400-foot reels)	17,000	5,000
Radar films (100-foot reels)	8,300	1,150
Satellite films (100-foot reels)	3,300	1,000
Climatological publications (back editions)	150,000	7,000
Unpublished tabulations and analyses	12,900	1,500

A discussion of the general data content of each of these categories follows.

Original Records

Occupying more than 10 miles of shelf length in the NWRC archives are most of the original manuscript observational forms and autographic traces that have been created at all weather stations operated by the U.S. Government (Weather Bureau, Air Force, Army, Navy) and its cooperators since the systematic collection of meteorological data began. A few original manuscripts of observations made prior to the establishment of the Weather Bureau are available only at the National Archives, Washington, D.C., and some have been destroyed after microfilming. Numerous changes have been made over the years in the forms of recording meteorological observations, and, in some cases, a particular element may not have been recorded continuously.

Original records in the NWRC archives contain literally trillions of meteorological measurements. Figure 3 is a photograph of shelves of manuscript data. Using the Washington, D.C. Weather Bureau station as an example, figure 4 illustrates the large amount of information at the NWRC about the weather history for a typical location that has had a long-established Weather Bureau office. Periods of record and observational programs vary considerably from station to station.

In addition to the records from stations in the United States, the archives contain the original manuscript observations of the military weather services from bases in foreign countries. The NWRC also collects in-flight reports from military and commercial aircraft. Ship observations in the archives include those from the stationary Ocean Station Vessels in the North Atlantic Ocean and the North Pacific Ocean; specially-instrumented ships

FIGURE 3

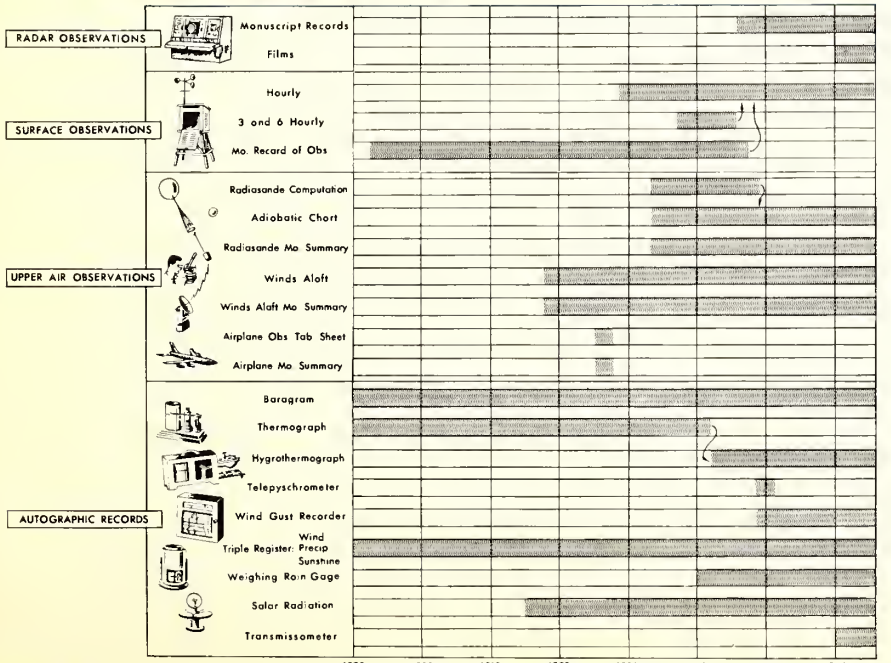


FIGURE 4

Periods of Original Records for Washington, D.C.

of the Navy, the Coast and Geodetic Survey, and other government agencies; Great Lakes ships; and merchant vessels on the oceans.

Station Networks. The discussion of station networks which follows is limited to the four basic networks and the supplementary networks of weather observing stations which are used by the Environmental Data Service **to determine the climate of the contiguous States.** These networks exclude weather observing stations of the military weather services and many Weather Bureau stations. Similar networks exist in Alaska and Hawaii, and in other countries. In addition to the data holdings from stations in the networks presented here, the NWRC's Information Bank contains data from all of the excluded stations in the United States and from many of those in foreign countries.

Basic Networks. The four basic networks which define the climate of the contiguous States are (1) the Climatological Bench-Mark stations with long records of temperature and precipitation, chosen for continuity value and prospective permanence, (2) the network of Principal Climatological Stations, called the 24-hour climatic network, (3) the network consisting of the foregoing plus additional cooperative climatological stations, called the "a" network, and (4) the Upper Air Network.

The Climatological Bench-Mark Network. The primary purpose of this network (figure 5) is to collect data in local environments with minimal anticipated man-made changes, so that they are suitable for monitoring climatic changes. The number of stations considered necessary for this purpose is between 30 and 50 in the contiguous United States. Eighteen have thus far met the strict criteria involving stability of location, free-

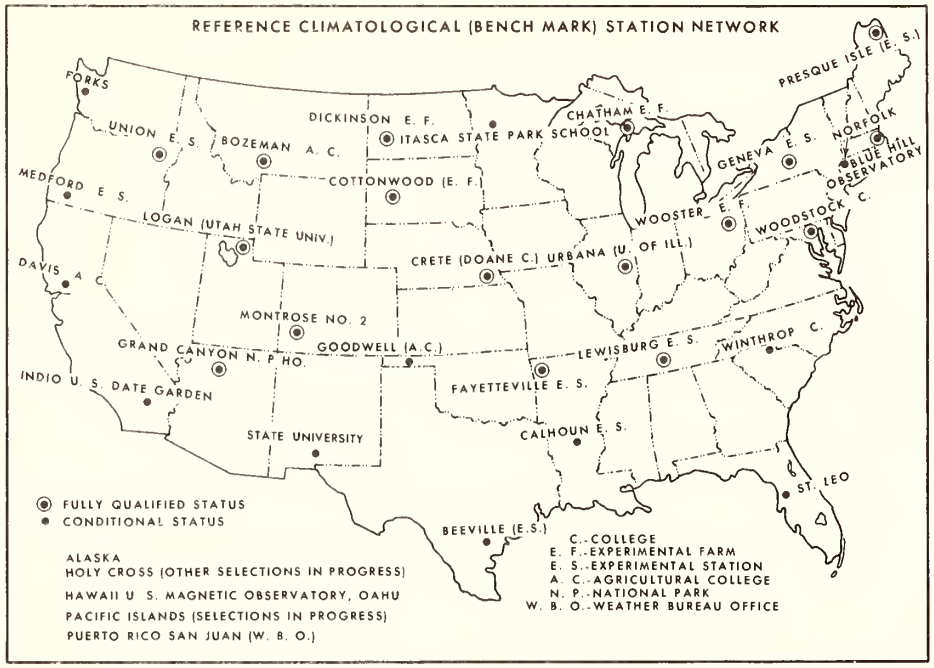


FIGURE 5

dom from environmental influence and change, reasonably long history of homogeneous observations, and good prospects of future continuity. The stations are located for the most part on property owned by the Federal or State governments or public institutions (e.g., in National Parks, at Experiment Stations, and on university campuses) where supervision of the observing program, uniform instrument exposure, completeness and accuracy of record, and freedom from molestation are fairly well assured.

The 24-Hour Climatic Network. This network consists of approximately 180 selected First Order Weather Bureau and Federal Aviation Agency stations. With few exceptions, these stations record a complete surface weather observation each hour. Although far less numerous than cooperative stations, these 24-hour stations constitute a fairly uniform national grid (figure 6). They add to the data obtained by stations in the "a" network (see below) by providing dependable records of climatic elements not observed at cooperative "a" stations, and they supply data which indicate the diurnal variation of temperature, wind, pressure, cloudiness, and other weather characteristics.

The "a" Network. This network consists of about 5,000 temperature and precipitation stations manned for the most part by cooperative volunteer observers. The network includes only those stations required to provide an adequate sample of data for areal statistics on weather and climate. It ordinarily contains about one station per 600 square miles. Figure 7 shows the "a" network in Ohio. There are similar networks in all other states.

The Upper Air Network. Sixty nine Weather Bureau rawinsonde stations make up that portion of this global network which is contained within the contiguous States (figure 8). Observations of wind, temperature, pressure, and humidity at these stations are made to altitudes of at least 100,000 feet. Data from this network are used climatologically to gain a more thorough knowledge of the atmosphere's behavior and to provide guidance in such activities as (1) designing aircraft and space vehicles, (2) aviation operational planning, and (3) planning against dangers from nuclear fallout.

Supplementary Networks. Two additional networks, called the "b" (hydrologic) network and the "c" network, assist in analyzing the climate.

The "b" Network. That portion of this network in the contiguous States is comprised of over 12,000 precipitation-observ-

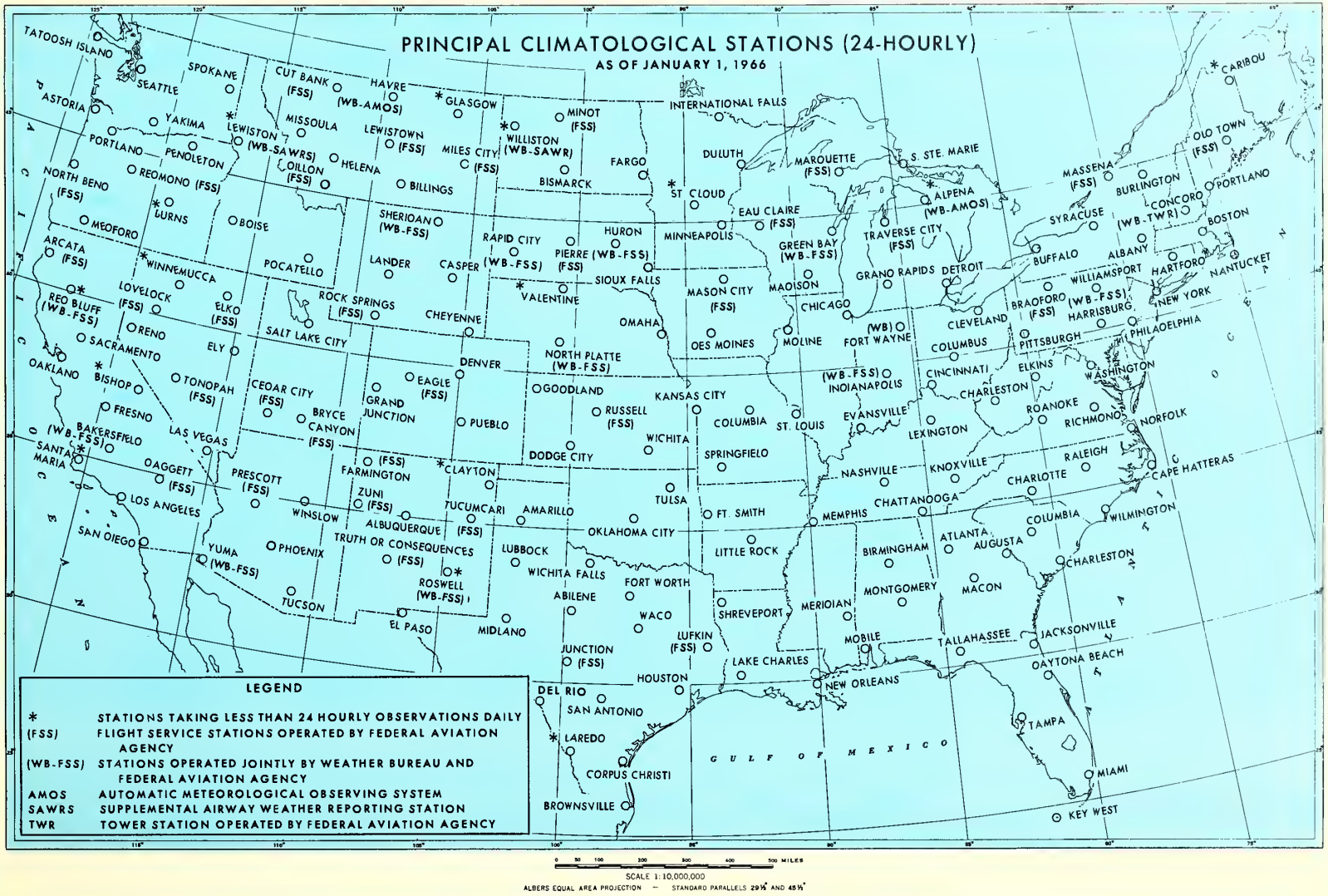

PRINCIPAL CLIMATOLOGICAL STATIONS (24-HOURLY)
AS OF JANUARY 1, 1966
LEGEND
* STATIONS TAKING LESS THAN 24 HOURLY OBSERVATIONS DAILY
(FSS) FLIGHT SERVICE STATIONS OPERATED BY FEDERAL AVIATION AGENCY
(WB-FSS) STATIONS OPERATED JOINTLY BY WEATHER BUREAU AND FEDERAL AVIATION AGENCY
AMOS AUTOMATIC METEOROLOGICAL OBSERVING SYSTEM
SAWRS SUPPLEMENTAL AIRWAY WEATHER REPORTING STATION
TWR TOWER STATION OPERATED BY FEDERAL AVIATION AGENCY
GULF OF MEXICO
SCALE 1:10,000,000
ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°

FIGURE 6

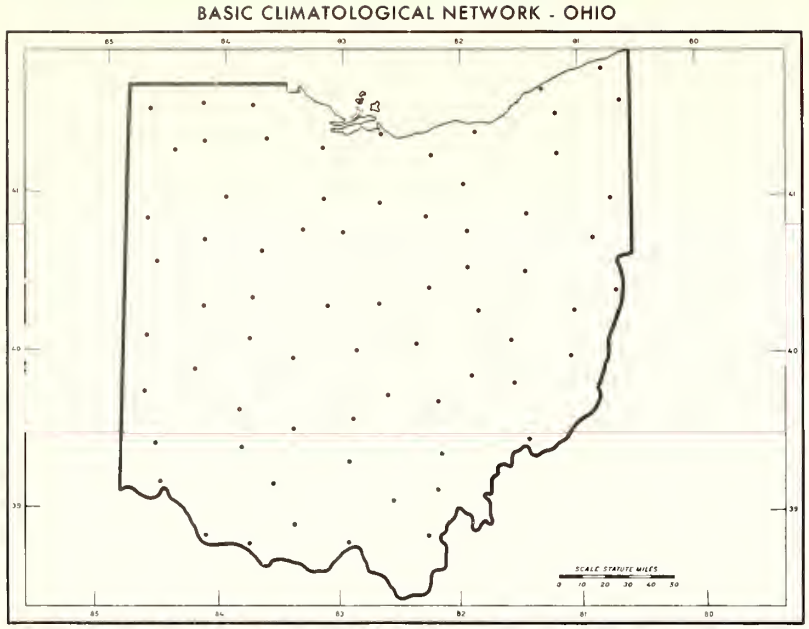


FIGURE 7

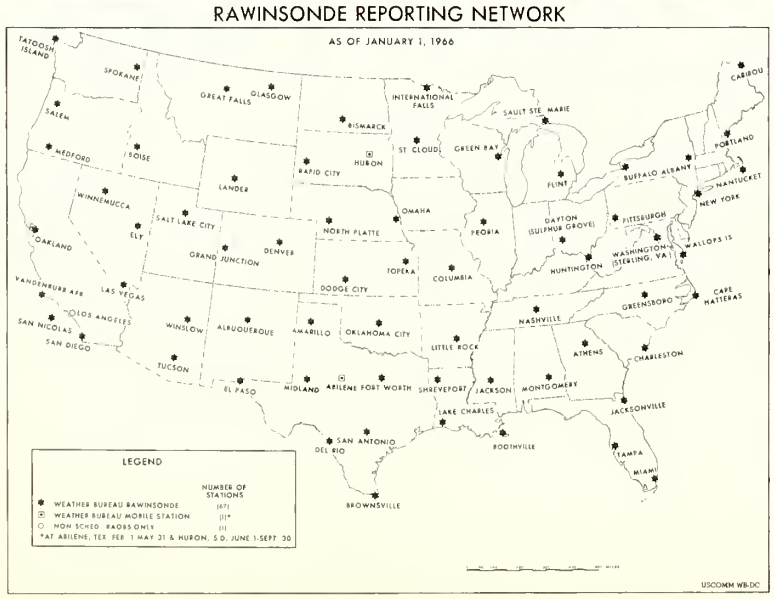

RAWINSONDE REPORTING NETWORK
AS OF JANUARY 1, 1966
LEGEND
NUMBER OF STATIONS
WEATHER BUREAU RAWINSONDE (67)
WEATHER BUREAU MOBILE STATION (11)*
NON-SCHED RAOBS ONLY (1)
*AT ABILENE, TEX. FEB 1-MAY 31 & HURON, S.D. JUNE 1-SEPT 30
USCOMM WB-DC

FIGURE 8

ing stations. About 2,700 of these stations record precipitation on an hourly basis. Readings from these stations are used primarily in river and flood forecasting, but they are valuable climatologically as well. Of course, many of these stations are also in the "a" network.

The "c" Network. Another group of about 800 substations is generally referred to as the "c" network. It is not a network in the true sense because the stations comprising it do not follow a planned system for one specific purpose sush as those that make up the "a" and "b" networks. These "c" stations consist of (1) those required primarily for local public services; (2) those having a long period of record but which are not in the "a" or the "b" network; and (3) special-purpose stations such as those at experiment stations or research farms, at tower sites, and those reporting soil temperature or soil moisture data.

Microfilms

Weather records are microfilmed to (1) secure the original data against loss, (2) permit disposal of the bulky paper originals when it becomes unnecessary to retain them, and (3) provide users with copies of large quantities of data at low cost and in a convenient form.

Selected weather records have been microfilmed routinely for more than two decades. Some of the more active records have been microfilmed on an annual basis for more than a decade. Either 16 mm. or 35 mm. roll film is used. Document sizes vary widely, but an average reel of 16 mm. microfilm contains about 2,000 pages of record: an average 35 mm. reel contains about 1,000 pages of record. Microfiche (multiple-image sheet

film) is prepared from some of the 16 mm. and 35 mm. film.

Perhaps the magnitude of data holdings on microfilm can be illustrated by stating that the cost to duplicate the NWRC's entire microfilm library for a requester would be about $350,000.

Punched Cards

A punch card is a paper card of uniform size and thickness, containing 80 columns of 12 rows each in which coded digital or alphabetic data may be punched and from which information may be entered into a computer. These cards are punched at central locations or at the observation station by the meteorological services of the United States and many foreign nations.

Weather records on punched cards in the NWRC's files come from every corner of the globe, including the ocean areas. Although no special emphasis is placed on gathering foreign data, large volumes of cards from foreign countries are added to the collection each year. Teletypewriter collections and data in bulletins or code sheets from foreign meteorological services are transferred to punch cards, and many other cards are received from foreign countries through exchange programs.

More than 500 different card decks containing coded weather observations are on file in the punched card library at the NWRC. An example of one card format of a surface observation is shown in figure 9. It is difficult to reduce the number of punched card formats because of variations from one country to another in units of measurements, observing practices, and codes. Some of these decks are used frequently, and it is important that the specific instructions used in compiling each deck be

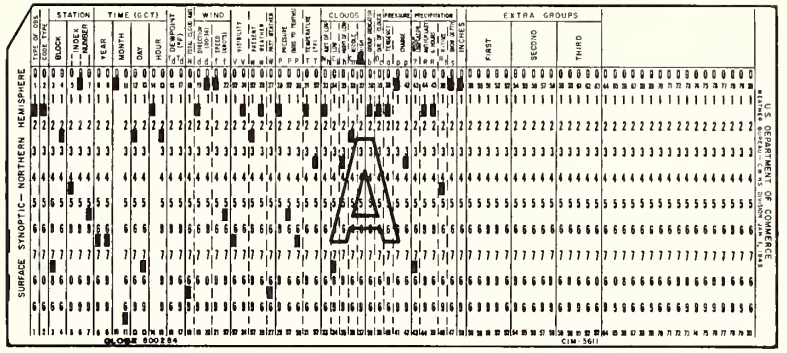


FIGURE 9

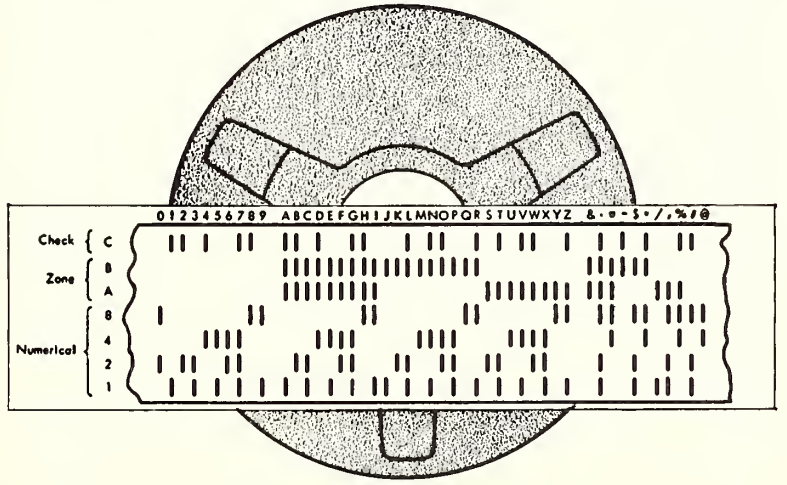


FIGURE 10

recorded and retained in a factual and accessible arrangement. This is accomplished by preparing a separate reference manual for each card deck and revising it as necessary to reflect changes in observing and punching practices.

A standard International Marine Card is now in use as a result of many years of negotiation with foreign countries through the World Meteorological Organization. Here, in addition to using the same card format, all nations follow identical card punching instructions. This is a great step forward in the preparation of ocean weather charts and special marine weather summaries.

Card holdings of domestic data are increasing daily. Observations are punched into cards for machine edits and summarizations prior to their publication. Manual edits of observations flagged by the computer are made, using both the applicable punched cards and the original records. In some cases, punched cards are transferred to magnetic tape for further machine processing of the data.

Another source of weather data on punched cards has resulted from cooperative agreements with universities, in which the NWRC furnishes copies of current punched cards in exchange for cards punched by the university for the same stations for earlier years of record.

Card decks are removed from the files to make way for additional data after placing images of the cards on microfilm for permanent retention. A 16 mm. camera fitted to a punched card feed assembly microfilms about 24,000 cards per hour. The film image represents a reduction in file space of 180 to 1. Over 40 percent of the total number of punched cards that the NWRC has collected are on microfilm. The film image can be used as a direct input medium to a machine which reproduces the actual cards when they are needed. This machine, named FOSDIC (**F**ilm **O**ptical **S**ensing **D**evice for **I**nput to **C**omputers), recreates punched cards at the rate of 100 per minute, or it can selectively scan up to 10 card columns and punch only those cards meeting certain specifications. New equipment is being developed which will produce a magnetic tape of the data directly from the microfilm.

Magnetic Tapes

Magnetic tape is a continuous strip of plastic with an oxide coating, usually one-half inch wide and 2400 feet long. All tape systems utilize some form of binary notation: a position on tape is either magnetized or not. The relationship of such binary "bits" on the tape determines the tape "code." A magnetic tape using a "seven-level" code is illustrated in figure 10. Four channels, representing 1, 2, 4, and 8, are required for recording numeric data. Two additional channels make possible the coding of alphabetic and special characters, algebraic signs, etc. The seventh channel is used internally by the computer as a checking device to assure that the characters represented are read and written correctly.

The NWRC's tape library contains approximately 2,000 reels of magnetic tape. These tapes contain a variety of meteorological data, such as hourly surface observations, summary of the day data, rawinsonde observations, marine data, and solar radiation data obtained from the TIROS series of meteorological satellites.

In addition, the Data Processing Division of Air Weather Service, collocated with the NWRC, maintains a tape library containing approximately 15,000 reels of magnetic tape. The meteorological data on these tapes are available to the NWRC for processing to fill specific requests. In general, these tapes contain similar types of data to those in the NWRC library.

Radar Films

Weather radar enables the meteorologist to observe storms and other severe weather in great detail. Advances in radar technology have been rapid since the development of radar during World War II. Since the late 1950's, time-lapse cameras have been mounted above the radar scopes at 41 major airports to photographically record the radar images at specific intervals during periods of severe or unusual weather. There are plans to increase this coverage by at least 10 more stations. These cameras were 16 mm. until mid-1964, when they were replaced by 35 mm. cameras. In addition to its operational uses, a time-lapse film copy of significant weather as seen by radar is preserved for subsequent reference and other uses, including severe storm research. The film-producing stations are located across the United States in a pattern which provides the best possible coverage in hurricane and tornado areas. A radar film quality control program is carried out by the NWRC to help the stations improve the quality of the film even more. Figure 11 is a photograph of the radar scope at Miami, Florida on September 8, 1965. On a 100-mile range, the radar shows the eye of Hurricane Betsy to be centered about 55 miles southeast of the station. The eye has a diameter of about 40 miles. The other radar scope photograph,

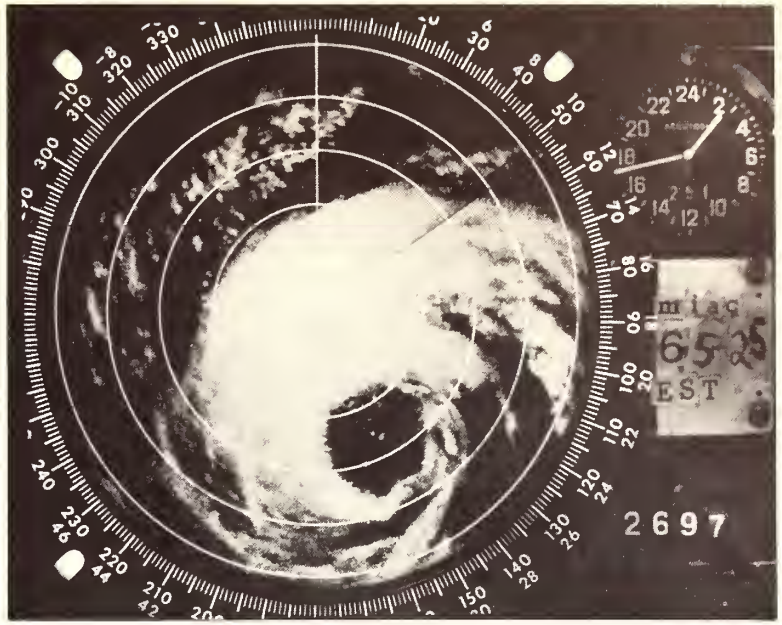


FIGURE 11

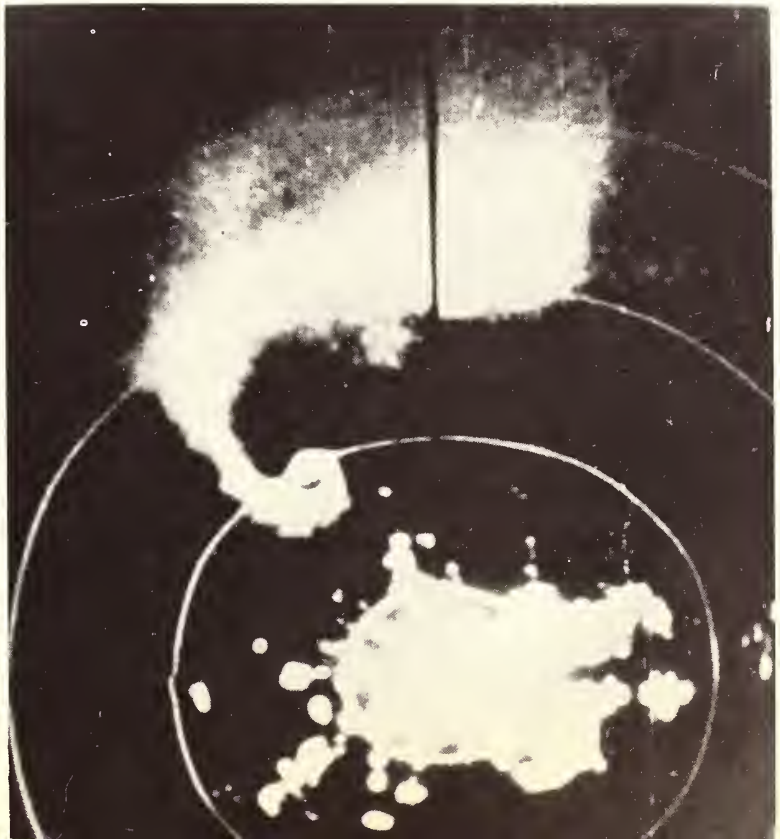


FIGURE 12

figure 12, shows the "hook" echo associated with a tornado at Meriden, Kansas on May 19, 1960, as seen by the nearby Topeka radar. Range circles are at 5-mile intervals.

There are approximately 100 weather radar stations in the United States, but only 41 with film-producing capabilities. All of these stations use a standard "Radar Observational Form" to record weather as seen by radar. The count of these forms in the NWRC archieves is included in the total for original records. Observations are recorded houly while echoes are visible on the scope and more frequently during periods of severe weather.

Satellite Films

Cloud Photographs. TIROS I, the World's first experimental meteorological satellite, was placed into orbit April 1, 1960. Immediately, it began to transmit what its television cameras saw —cloud formations and those portions of the Earth's surface unobscured by clouds. Ten of the thirteen meteorological satellites that have been orbited were in the TIROS series. NIMBUS I was the next to be placed into orbit and more recently, ESSA I and II, the first two in the "operational" series, were providing global data on a continuing basis. Figure 13 is a photograph of Western Europe as viewed from NIMBUS I in September of 1964. The pictures obtained by television cameras on the weather satellites are transmitted to receiving stations and recorded as individual pictures on 35 mm. roll film. In general, the film is of high quality and is available for reproduction. Contrast is sufficient to permit recognition by the untrained eye of cloud borders, coastlines, etc. Latitude-longitude grids are also available for use with the satellite photography.

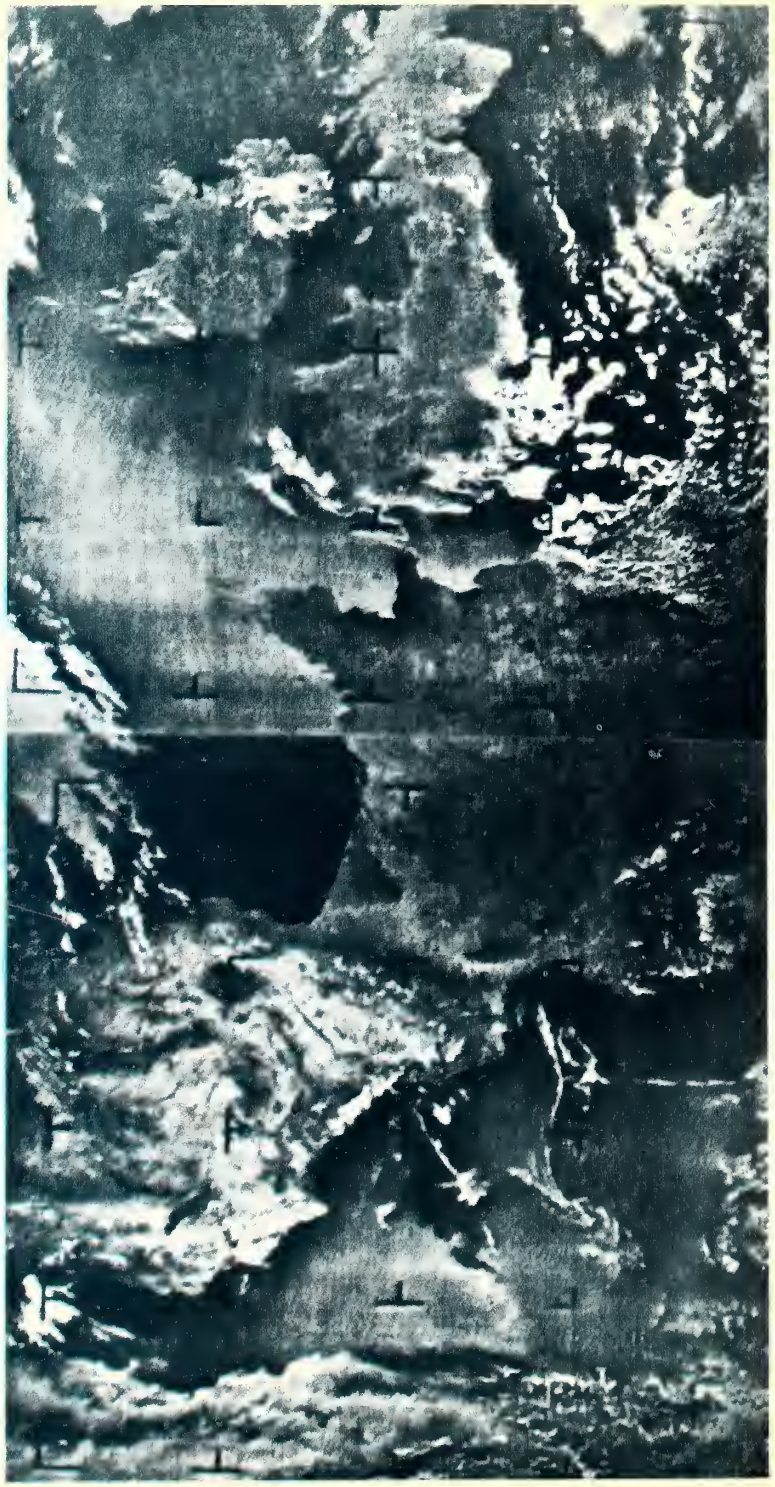


FIGURE 13

Copies of all weather satellite films are retained at the NWRC and are reproduced for users on request.

Radiation Data. A few of the meteorological satellites have carried a medium-resolution scanning radiometer which has channels sensitive to several different types of radiation. Some of the channels of the radiometer respond to reflected solar radiation, and some are sentitive to emitted thermal (long-wave) radiation from the Earth and its surrounding atmosphere. When a satellite passes within range of a Command and Data Acquisition Station, radiation data are transmitted from the satellite to the station. These data, along with orbital, altitude, and calibration data, are incorporated in a computer program to produce (in binary form) the "Final Meteorological Radiation Tape," which is the primary repository of all radiation data.

In addition, infra-red equipment is used by the satellite to detect cloud formations and types at night, thus supplementing television photography by providing information on clouds present over that portion of the Earth in darkness.

Nephanalyses. Nephanalyses, analyses of weather situations in terms of types and amounts of clouds, are derived from the cloud photographs obtained from the satellite. These analyses can be prepared only for those times when the satellite is in an optimum position to transmit to either the readout station at Fairbanks, Alaska or the readout station at Wallops Island, Virginia.

There is considerable lag between preparation of nephanalyses and microfilming, but many of these analyzed cloud patterns are available on film.

Climatological Publications

As a public service, many of the data obtained from Weather Bureau and cooperative stations are summarized and published in a form preferred by the greatest number of users. Each year more than 1.7 million publications are mailed to subscribers as soon as printed. (Publications are discussed at greater length in the next section.)

Published climatological data also becomes an information resource, both for internal and external use. In connection with the latter, 8,200 individual requests are filled in an average year by furnishing back-issue publications containing data that requesters need. In the files are one or more copies of 150,000 back editions of data published by the NWRC, each distinct from the others.

As a result of international exchange agreements, equivalent climatological publications of many foreign meteorological services are obtained and kept for reference. This collection constitutes an extremely valuable data source and has enabled the NWRC to further expand its service capability. The file of foreign data publications is growing at the rate of about 8,000 per year.

Unpublished Tabulations and Analyses

Also discussed at greater length in a subsequent section, unpublished tabulations and analyses prepared to meet specific user requirements constitute an increasingly valuable pool of information. A copy of each tabulation or analysis completed for the customer is kept for reference by the NWRC staff and is also available for duplication for subsequent users.

PHYSICAL RESOURCES

MACHINES

After Hollerith invented and successfully employed semi-automatic equipment to process the mass of data from the 1890 census, businessmen and scientists eventually realized the advantages offered by such machines in their own fields. The systematic use of machines to process weather data, which began in the United States in the mid-thirties, has contributed significantly to the advance of climatology as a science. The punched card is the very heart of this earlier system.

Advances in machine technology have caused significant changes at the NWRC in methodology and operation. Electronic computers are used extensively. These computers can perform all operations which are accomplished by electro-mechanical equipments, and more. The main difference between the two types of machines, however, is the speed with which calculations are made. Using a stored program written to accomplish a specific task, the computer performs arithmetic computations, makes logical decisions, and prints results, all at very high speeds. The data to be processed, the set of instructions comprising the program, and the results of the calculations are stored in the computer's memory as long as required. Input to the computer can be either magnetic tape or punched cards.

Computer technology is advancing so rapidly that computers are almost obsolete by the time they become operational. Although tomorrow's computers will have even greater capability, those of today are most important tools for meteorologists and climatologists. They provide summarizations of data and climatological studies of much greater complexity and scope than earlier systems could accomplish. New techniques in time and space correlation, in numerical weather prediction, and in all facets of applied climatology will continue to place heavy demands on the electronic data processing facilities of the nation's weather agencies.

The NWRC operates both a modern computer complex (figure 14) and a set of conventional electro-mechanical punched card machines. Each project is evaluated to determine which system (or, in some cases, manual effort) is the most economical, efficient, and effective.

CLIMATOLOGICAL PUBLICATIONS

Publishing climatological information has been part of the overall program of the national weather service almost as long as there has been such a service. The number of people seeking climatological information is so great and the uses made of the information so variable that it would be almost impossible to furnish everyone (through publications) with the exact information he wants. Rather than to serve specific applications, climatological publications make basic data available on a broad scale.

Tremendous quantities of data appear in the 30,000 individual pages of climatological publications issued each year. While 1,700,000 copies of various climatological publications are mailed to subscribers, 325,000 additional copies are used in a typical year to answer requests for data.

Those publications in greatest demand are described below. Additional information on those included here and on other climatological publications may be found in "Selective Guide to Published Climatic Data Sources," Key to Meteorological Records Documentation No. 4.11. It is available through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

All of the types of data mentioned in the descriptions which follow may not be available for every station included in the particular publication under discussion. Moreover, the data may not be presented exactly as you might want it. The surest way to obtain precise and complete information on what data are available for a particular station of interest and the forms in which data for that station are published is to contact the NWRC. If the data are not published in the form you need them, in most cases we can prepare the data presentation to your specifications.

SUBSCRIPTION PUBLICATIONS

Subscription publications are issued on a scheduled periodic basis. Orders for subscriptions should be sent of the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Back issues for recent years are usually available at the NWRC.

"Local Climatological Data"

This monthly publication is prepared separately for approximately 300 cities and towns, all with government-operated weather stations. It contains daily information on temperature (including heating degree days), dew point, precipitation (including snowfall), pressure, wind, sunshine, and sky cover. Monthly averages or other appropriate summarizations of these elements are presented. The month's accumulation of rainfall is shown in hourly amounts. If the particular station operates at all hours, eight almost complete meteorological observations per day at 3-hourly intervals are listed. A monthly average for certain times of the day is indicated for some elements.

"Local Climatological Data" is generally uniform in format for all stations. Subscription to this publication includes the annual summary described below, but, as is the case with all climatological publications, single editions are available on request.

"Local Climatological Data with Comparative Data"

This annual publication is prepared for the same localities as the monthly publication described above. It summarizes by month and for the year the data recorded during the past calendar year. A table of normals, means, and extremes, based on long periods of record, is presented for the same elements. In addition, tables of average monthly and annual temperature, precipitation, snowfall, and heating degree days cover a long period of record. Also contained in the annual issue are a brief description of the climate of the locality and a detailed history of the weather station.

"Climatological Data"

This monthly publication contains primarily daily measurements and monthly summaries of precipitation and temperature extremes at cooperative stations. Issued separately for each State (or a combination of States), a station listing is included. A locator map is included when space permits. Observations from government-operated stations are used to fill data gaps. Supplemental data on evaporation, wind, relative humidity, sunshine, or soil temperature are included for stations making any of these measurements. Seasonal tables for heating degree days and snowfall are published in the July issue.

The stations for which data are presented in the annual issue of this publication are the same as for the monthly. The annual issue contains monthly and annual averages and departures from long-term means of temperature, precipitation, and evaporation; total wind movement; soil temperature and soil moisture table; a table of temperature extremes and freeze data; a station index; and a locator map.

"Climatological Data, National Summary"

Issued monthly, this publication contains pressure, temperature, precipitation, and wind data for selected U.S. stations. A general summary of weather conditions over the country is presented, and special articles describe hurricanes, unusual weather, and river and flood conditions. Severe storm damage is summarized by States. Monthly averages of rawinsonde data are presented in tabular form. Daily and monthly values of solar radiation are included. Charts graphically portray temperatures, precipitation, snowfall, percentages of sunshine; tracks of cyclones and anticyclones, solar radiation, monthly average upper air winds, and heights of constant pressure surfaces.

The annual issue presents summaries of all the above data for the year, and includes information on excessive rainfalls, hurricane tracks, and tornado paths.

"Hourly Precipitation Data"

This publication is issued monthly and separately for each State (or a combination of States) except Alaska. Hourly and daily precipitation values are presented for stations equipped with automatic recording gages. The annual issue contains monthly and annual totals of precipitation.

"Storm Data"

Issued monthly and including data for each of the 50 States,

this publication presents the place, time, character, and estimated damage of all reported severe storms or unusual weather phenomena. Data are divided by State and place within the State. No annual summary is issued in this series.

"Monthly Climatic Data for the World"

This publication contains monthly mean values of surface and upper air measurements from a large number of selected stations throughout the World. The surface elements included are pressure, temperature, relative humidity, and precipitation. The upper air data consists of the height, the temperature, the dew point, the wind direction, and the wind speed at standard constant pressure levels.

"Monthly Climatic Data for the World" is sponsored by the World Meteorological Organization in cooperation with the Environmental Science Services Administration. There is no annual issue of this publication.

"Northern Hemisphere Data Tabulations"

This publication, for the most part, contains the surface and upper air reports which are collected by forecast centers and the National Meteorological Center via rapid communications for synoptic analyses and prognoses. The NWRC issues the tabulations several months after the observations were made and supplements through foreign data publications and other sources those reports collected on a real-time basis. Included are sufficient data distributed so that an analysis of the Northern Hemisphere's circulation could be made for any standard pressure level desired. Surface synoptic data, issued only for 1200 GMT, are separated into land reports and marine reports. Radiosonde and rawinsonde data for standard pressure and significant levels at 0000 GMT and 1200 GMT are presented for North America (WMO Region IV), the Atlantic and Pacific Ocean Weather Stations, and for selected stations outside Region IV including Greenland and the North Pacific Ocean. These data include upper winds for all standard pressure levels at stations in the United States. Radiosonde and rawinsonde reports for the remainder of the Northern Hemisphere are published for the 0000 GMT observation only. Included are significant levels and those standard pressure levels which are mandatory under existing coding practices for long-line transmission. Upper wind reports for Northern Hemisphere stations outside the United States are included, as available, for four times a day (0000, 0600, 1200 and 1800 GMT). Data for each day are presented, and data for any particular day are available in the form of microfiche. Monthly collections of daily data are available on microfilm reels.

"Northern Hemisphere Sea Level Charts and 500-Millibar Charts"

This is a series of daily synoptic weather charts, each volume consisting of charts of the Northern Hemisphere for one month. One sea level chart and one 500-millibar chart are presented for each day. Both are prepared from data observed at 1200 GMT. The series begins with data for January 1899, but some of the back issues are in limited supply or out of print.

"Weekly Weather and Crop Bulletin

Especially valuable to agriculturists, this publication is prepared by our parent organization, the Environmental Data Service, and distributed from Washington, D.C. about noontime each Tuesday. Crop data are collected by the U.S. Department of Agriculture and State agricultural agencies. In addition to the narrative summaries of the weather over the country and its effects on crops, condensed summaries furnish this information for each State. In season, small grains, pastures, corn, cotton, soybeans, and other crops are discussed separately. Tabular weather information consists of summaries of temperature, heating degree days, precipitation, and snow depth on the ground. Ice thickness in rivers, harbors, and lakes is included during the winter season. During the spring, a summary of ice conditions on the Great Lakes is featured prior to the opening of the shipping season. Special articles on subjects of general interest to agriculture, such as droughts, are added from time to time, as well as charts and tabulations of current importance. Drought analyses are made weekly for any areas having a deficiency of precipitation for an extended period of time, using a formula known as the Palmer Index. These analyses are presented in chart form in terms of drought severity one week after the temperature and precipitation measurements are made.

A monthly chart portraying weather highlights over the country and the Monthly Weather Outlook, prepared by the Extended Forecast Division of the Weather Bureau, are also included in this publication.

UNSCHEDULED PUBLICATIONS

The first two of the non-subscription publications described here are updated at roughly ten-year intervals with no specific deadlines for their release. Latest issues cover the period 1951–1960. The other four are updated and expanded as workload and funds permit. All of these publications generally are available through either the Superintendent of Documents or the NWRC. Requests for information on their availability should be directed to the National Weather Records Center, Federal Building, Asheville, N.C. 28801. Those publications that are out of print, in most cases, can be obtained from the NWRC for the cost of publication.

"Climatic Summary of the United States—Supplement for 1951-1960"

This summary is issued separately for each State (or a combination of States) and contains monthly total precipitation, monthly mean temperature, and monthly total snowfall for the ten-year period, as well as averages for the entire period of record. These data are presented for 100 to 200 locations within the State. Normals are included for those stations having 30 years or more of continuous record. Miscellaneous tables provice additional information on temperatures, precipitation, and evaporation. An index shows the history of each station location. Early issues of this publication in 1909, 1920, and 1930 were commonly referred to as Bulletin W, although its official title was "SUMMARY OF CLIMATOLOGICAL DATA FOR UNITED STATES BY SECTIONS." A supplement was issued

in the mid-fifties for the period 1931–1952. The next edition in this series will be a supplement for 1961–1970.

"World Weather Records"

This publication contains tables of mean temperatures, mean pressures, and precipitation at all stations throughout the World for which complete data for the ten-year period are available. There are earlier issues covering every ten-year period back to about 1900.

"Climates of the States"

This unscheduled publication is issued for each State (or a combination of States) and contains a local climatological data summary for each Weather Bureau station in the State, a freeze data table for 100 to 200 locations, depending on the size of the State, and a narrative summary describing the climatological features of the State.

"Climatological Substation Summaries"

Climatological summaries similar to the annual issues of "Local Climatological Data" described previously, have been issued for various cooperative stations in each State. These stations are at locations where there is no full-time Weather Bureau office. The number of these summaries varies from a few for some States to as many as a hundred in others.

"Climatic Guides"

Climatic guides have been issued for some of the larger cities. They contain a wide variety of tables and charts of particular interest to the locality. A narrative summary of general climatic conditions in the surrounding metropolitan area is also included.

These summaries have been published for 138 Weather Bureau stations where 24 hourly observations are recorded daily. Of the total number of summaries completed, 102 cover the ten-year period 1951–1960. The other 36 are based on the five-year period 1956–1960.

Tables give percentage frequencies of wind directions and speeds, ceilings and visibilities, and weather conditions of various types. Additional tables show hourly and daily occurrences of precipitation amounts by category, and total occurrences of various ranges of relative humidity under categorized temperature and wind conditions. A narrative description of the location and the topography of the station, together with one pertaining to smoke sources, is included. Where available, a smoke source map of the local area is shown.

This series supersedes the series entitled "Climatography of the United State No. 30—SUMMARY OF HOURLY OBSERVATIONS," a five-year summary published in 1956.

SPECIAL SERVICES

In addition to issuing and disseminating climatological publications, the following services are performed in a typical year by the National Weather Records Center (as of May 1966):

- 419,000 copies of weather records are made
- 24,000 certifications of weather records are furnished for use in litigation and insurance settlements
- 15,000 telephone queries are answered
- 6,925 one hundred-foot reels of microfilmed climatological information are duplicated and mailed to requesters
- 2,500 one hundred foot reels of climatological data are microfilmed (equivalent to 2,000,000 sheets of weather records)
- 4,100 one hundred-foot reels of microfilmed climatological information are added to the archives from other sources
- 3,000 office visitors are served
- 1,500 unpublished tabulations and analyses are produced

At the present rate of growth, by 1970 the annual volume of services will have reached approximately the following levels:

- 750,000 copies of weather records made
- 41,000 certifications of weather records furnished for use in litigation and insurance settlements
- 15,000 telephone queries answered
- 8,000 one hundred-foot reels of microfilmed climatological information duplicated and mailed to subscribers
- 4,400 one hundred-foot reels of climatological data microfilmed (equivalent to 3,520,000 sheets of weather records)
- 4,100 one hundred-foot reels of microfilmed climatological information added to the archives from other sources
- 3,000 office visitors served
- 2,200 unpublished tabulations and analyses produced

Perhaps it is difficult for one who has never used climatological data in his business or profession to understand why there is such great demand for information on past weather. Typical users of climatological information are indicated in figure on (page 31).

This list is by no means complete, but it serves to illustrate that knowledge of climatic conditions can be of value to all of us in connection with just about any conceivable type of activity. The following discussion describes those climatological services offered by the NWRC other than that of publishing climatological information.

DATA TABULATIONS

While publications may be considered the standard method

of presenting climatological data, special hand and machine tabulations often are necessary to bridge the gap between published data and the original observations. An important part of the NWRC's mission is to help solve individual problems by furnishing data in the form and quantity needed.

Special tabulations or summaries may be prepared on request. The customer pays the cost of such service. It is important before any work is begun tnat NWRC personnel and the customer agree as to exactly what data are needed and the specifications of the finished product. Among the items which need to be clearly specified are the elements, the stations, the period(s) of record, the manner in which the data are to be presented, etc. For example, the customer may want a machine printout of a bivariate (two elements) or a trivariate (three elements) frequency distribution. An example of the latter for which the NWRC has frequent requests is a distribution of temperature by groupings of wind speed and relative humidity values. Such information has a variety of applications. It relates to human comfort, for example, and is used in designing buildings, special-use clothing, air conditioning, etc. Another application of this information is in planning aviation and space operations. Jet aircraft and rocket engines are especially sensitive to temperature and wind factors.

Although one may thoroughly understand his need to apply climatological information to his problem, if he is unfamiliar with the peculiarities of the basic data, it may be difficult for him to clearly specify what he wants. To illustrate the situation he may encounter, let us examine one element, surface air temperature, for its vagaries. We will start with the assumption that all weather stations record the surface air temperature at regular intervals in degrees Fahrenheit. Now, this question arises: **What are the "regular intervals"?** The intervals at which temperature measurements are made vary with the type of station involved. We collect data from stations which report surface air temperature one, four, eight, twelve, or any number of times up to and including twenty four times each day. Some Weather Bureau stations obtain a continuous record of temperature.

The next question might well be: **What other kinds of temperatures are recorded?** Among the many other temperatures recorded are wet-bulb, dew-point, maximum, minimum, soil, sea-surface, etc.

The next logical question would be: **Do all stations record all of the temperature measurements mentioned above?** The answer to this is "no." In fact, a data survey is the first requirement of a large-scale job. Not only must the availability of the data for the job be determined, but just as important is a determination of whether or not the data are in a readily suitable form for machine processing.

If the data are not in suitable form for machine processing, the NWRC still can fulfill a request by hand tabulation. In cost estimating special data tabulations, the decision of whether to use a machine, hand tabulate, or use a combination of the two, hinges upon such factors as (1) the form(s) of available input data; (2) the size of the job as indicated by the number of elements, the number of stations, and the period of record involved; and (3) the statistical operations required. Every effort is made to furnish the specified tabulation or summary at the lowest cost possible.

SPECIAL SERVICES

We have prepared thousands of special data tabulations and summaries for customers. Several examples of the categories of application of these data and some of the elements involved follow:

AGRICULTURE

- drought
- evaporation
- freeze data
- precipitation
- temperatures
- wind speeds

AIR CONDITIONING

- dry-bulb temperatures
- wet-bulb temperatures

AIR POLLUTION

- inversions
- lapse rates
- mixing depths
- wind directions and speeds

AVIATION

- cloud-visibility distributions
- cross-wind components
- humidity and runway temperatures
- low ceiling-visibility wind roses
- temperatures aloft
- winds aloft

HIGHWAYS

- fog
- freeze data
- snow or ice cover
- strong winds

INSURANCE

- destructive winds
- drought
- excessive rainfall (including floods)
- hail
- hurricanes
- tornadoes

MEDICINE

- cloud cover
- humidities
- pressures
- solar radiation
- temperatures
- winds

OFFSHORE PETROLEUM EXPLORATION

- state of sea, wave height and direction
- storm frequency
- winds

RADIO AND TELEVISION

- refractivity
- maximum winds
- temperature extremes in connection with construction of towers

SPACE EXPLORATION

- densities aloft (includes humidities)
- temperatures aloft
- winds aloft

TRANSMISSION (petroleum and natural gas)

- duration of critical temperatures
- maximum temperatures
- minimum temperatures

A copy of each resulting tabulation or summary is retained in our files. New requests are reviewed in the light of these previous summaries. When one or more of them is pertinent to the customer's request, copies are provided at cost of reproduction. Most special jobs are unique, however. Previous summaries still have considerable value because often a method used in developing a previous summary can be adapted to the customer's needs. When this is possible, the customer's job usually costs less.

Data tabulations and summaries are furnished to anyone requesting them according to mutually agreed upon specifications. The NWRC assists the customer in determining his climatological data requirements but avoids infringement upon the domain of the private meteorological consultant in those cases where a private customer needs assistance in interpreting climatological information and applying it to his specific problem. All private customers needing special assistance are referred to the American Meteorological Society for a list of qualified meteorological consultants. In these cases, the consultant is encouraged to define what is needed from the NWRC and then interpret the data tabulation for his customer.

From time to time the NWRC participates in special data handling projects of particular benefit to groups of users. An example of this is a special collection of precipitation and temperature data via telephone each week. From these data, drought intensity indexes are computed and promptly sent to the Environmental Data Service. A map of the eastern United States appears each week in the "Weekly Weather and Crop Bulletin" one week after the observations and shows the current status of drought over this part of the nation.

CLIMATOLOGICAL INVESTIGATIONS

Climatological investigations are distinguished from data tabulations and summaries by their scope. These investigations usually are major jobs requiring tabulations and summarizations of climatological data, but they go beyond the results of machine processing and technical review. Interpretations of the results are applied to specific problem areas presented to the National Weather Records Center by our parent organization and other Federal agencies for solution. The National Weather Records Center usually carries these climatological investigations to their conclusions and often prepares reports on projects for publication. Numerous chart analyses and technical illustrations often are involved.

A few of the climatological investigations we have made for other agencies of the Federal Government are described below:

Environmental Studies for Aviation Operations

While polar flights to European cities from terminals on the West Coast and in Alaska are now considered routine, the inception of air travel over the Antarctic continent is a comparatively recent and still newsworthy accomplishment. An historic flight of two U.S. Navy aircraft was made from Cape Town, South Africa to McMurdo, Antarctica during the Fall of 1964. These planes flew directly over the South Pole. The passenger list was a veritable "Who's Who" of high-ranking naval officers, prominent scientists, and leading newsmen. As with previous flights of significant length over unusual routes, the NWRC was called

upon to assist in the pre-flight planning. Upper air observations and weather maps of the general area were studied. Meteorologists interpolated wind and temperature information over the vast ocean and continental areas where no observations were available. Electronic computers assimilated this information and correlated it with aircraft speeds and altitudes. The end product enabled selection of the best probable two-week period to accomplish the flight. This particular investigation was a relatively small job, but a very interesting one.

Studies of the type described above are essential when fuel capacities and aircraft loads are pushed to their maximum limits. The NWRC has already completed similar studies for selected routes proposed for use by U.S. supersonic transport aircraft under development. Investigations of environmental conditions in the 50,000 to 85,000-foot stratum for New York-Paris and San Francisco-Stockholm routes were made in this project conducted for the Federal Aviation Agency. Studies revealed that an aircraft flying at 2,000 knots would seldom encounter winds strong enough to deviate the flying time more than 2 or 3 percent at any time, even in Winter, on either route. Temperatures actually are more significant than winds in supersonic aircraft operations because the rate of fuel consumption is directly affected by temperature. It was found that summer stratospheric temperatures over the two selected routes were relatively constant. However, in winter, and especially over the polar area, temperatures fluctuated greatly at high altitudes within short periods of time.

The NWRC also has made a number of climatological investigations for the Federal Aviation Agency in connection with proposed instrument landing systems at air terminals. Briefly stated, incidences of low ceilings and visibilities, together with the volume of air traffic, largely determine if a particular airport needs to be equipped with an instrument landing system. Once a decision is made to thus equip the airport, studies of ceilings, visibilities, winds, and other climatological factors determine the particular runway, if one is suitable, for which the installation is made. An important consideration is the most frequent wind direction at times when ceilings and/or visibilities are low. Among many other considerations is the wind speed. The runway oriented closest to that of the prevailing wind direction under low ceiling and visibility conditions may be a short one relative to other runways at the airport. Wind speeds may become a more important consideration than wind directions in such cases.

Environmental Studies for Space Exploration

Due to the significant effects of meteorological factors on space vehicles, the National Weather Records Center has a continuing research program in support of America's space adventure. The Earth's atmosphere plays an important role in the design, launch, and flight of aerospace vehicles. Wind is especially important because the vehicle is designed to withstand certain critical wind speeds and wind shears at the launching pad and in flight. In preparation for a space flight, the vehicle is placed on its launching pad as long as two week prior to lift-off, to prepare it for launching. Winds near the ground, if strong enough, may damage or even topple the vehicle during this risk period of its

exposure to the elements. In order to assess the risk for these critical periods, the National Aeronautics and Space Administration has obtained the probabilities of various wind speeds for different hours of each day, different days, months, and seasons. The NWRC also furnishes wind probabilities for various exposure periods (four days, ten days, etc.) that the vehicle may be on the launching pad prior to lift-off.

A similar concern to the aerospace engineer involves the winds at different altitudes over the launching site. Of particular concern is the area of maximum wind speeds and wind shears where the vehicle might be deflected from its planned path if winds aloft exceed the design and operational criteria. Here again, probabilities of unfavorable wind conditions are important considerations in the planning for space flights and future vehicle design. NASA's requirements for upper wind studies at first presented a real challenge to the NWRC because the data for many levels were incomplete and radio wind soundings often did not reach levels as high as was needed to complete the information of concern to the space program. Although rocket soundings are becoming increasingly common, most upper winds still are determined by tracking a rising balloon with a radio transmitter attached. Wind information often cannot be obtained to desired altitudes for such reasons as the balloon bursting, a malfunctioning radio transmitter, loss of radio signal due to the distance between the transmitter and the ground receiver when very high wind speeds are encountered, and failure of ground tracking equipment. NASA sought complete wind observations up to altitudes of approximately 100,000 feet. Initial input data consisted of six-hourly winds aloft observations from selected stations for a number of past years. Current data are processed on a continuing basis to extend the period of record and thus provide a broader base for statistical applications. In order to fulfill this requirement, it was necessary to develop a method of meteorological analysis in which missing wind data could be estimated with reasonable accuracy. Of particular importance are estimations when high wind speeds cause termination of observations. The method developed by the NWRC to serially complete upper wind observations to 100,000 feet has resulted in wind data of sufficient accuracy to adequately meet NASA's requirements.

Other studies made for NASA involve the probable cloud cover for various launching times, the temperature and humidity environment the vehicle will encounter on its ascent, and the probabilities of suitable meteorological conditions being present over "splashdown" areas.

Taking all of the above factors together, probabilities of suitable meteorological conditions for launching at certain times of the year can be determined, thus giving the aerospace agency additional information useful in overall planning in the space program.

Air Pollution Studies

Air pollution, especially in industrial and urban areas, is a problem of growing national concern. In cooperation with the U.S. Public Health Service, the Weather Bureau Research Station at Cincinnati, Ohio has devised a method of computing and forecasting air pollution accumulation and dispersion. The role of the National Weather Records Center in this effort is to conduct statistical studies on vertical temperature distributions and

wind flow at various major cities. The project requires that the NWRC compute "mixing depth" values for each city. The mixing depth is the thickness of the layer of air above the surface in which mixing is restricted by specific conditions of wind speed and/or temperature during a given period. Normally, temperature decreases with height. Mixing of the layer of air near the surface often is restricted by very light wind speeds and a temperature inversion (temperature increasing with height) based a few hundred feet above the ground. Such conditions hold pollutants within the thin layer above the surface and allow continued accumulations until either the wind speed increases sufficiently to carry pollutants away, or until the surface temperature increases until it is warmer than temperatures aloft, thus wiping out the inversion. Once the warmest air is at the surface, then the fundamental principle that warm air rises comes into play. The rising warm air lifts the pollutants and leaves the air near the ground almost free of pollution.

A more serious pollution problem than the above may occur with light wind speeds when the temperature inversion is ground-based. In this situation the concentrated pollutants reach the ground and may seriously affect breathing in extreme cases. Such situations are apt to develop during the night and early morning when radiational cooling of the Earth is greatest. Although ground-based inversions are very persistent at times in some localities, in the typical case, warming of the Earth's surface by the late morning sun destroys this type of inversion by noon.

Also involved in this project are studies to determine the length of time certain wind and temperature conditions may exist in the lower atmospheric layers and how frequently they occur. This information may be used by authorities to control air pollution by placing restrictions on industries releasing various gases and combustion wastes when measurements of air pollution reach a specified limit. Restrictions would be lifted as soon as the meteorological conditions for dispersion had been met and the original pollution no longer remained.

Other special climatological investigations have been concerned with pollution of the air and ground by fallout of radioactive particles from nuclear explosions. Wind models were developed for the Office of Civil Defense for use in designating suitable areas to which large numbers of people could be evacuated in the event of a nuclear attack. Sites for nuclear reactors also are selected largely on the basis of climatology.

REPRODUCTION OF CLIMATOLOGICAL DATA

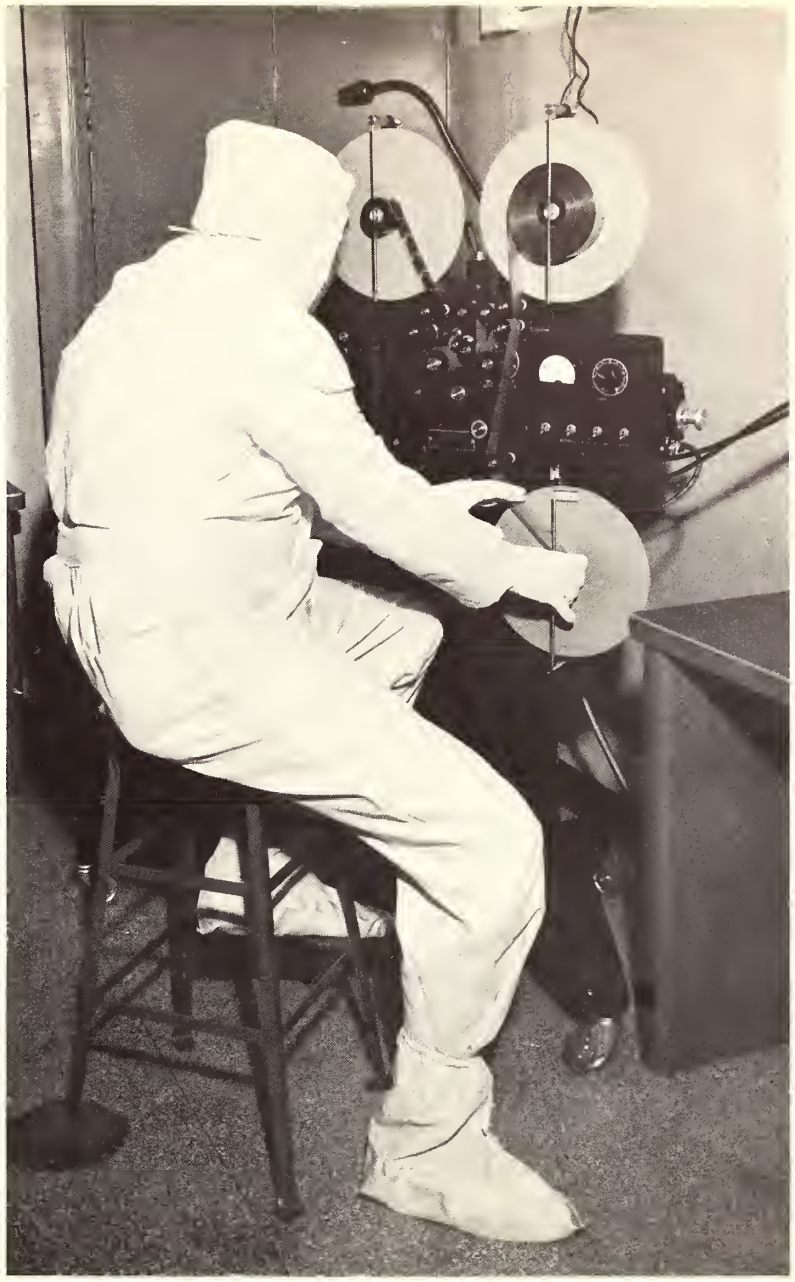
Although second to climatological publications in number of copies distributed, duplications of data in various media satisfy the needs of many customers. As indicated earlier, approximately 419,000 direct copies of weather records (manuscripts and autographic traces) and 6,925 one hundred-foot reels of duplicated climatological data on microfilm (equivalent to more than 5½ million sheets of weather records) are mailed to requesters annually. The NWRC has facilities to duplicate, or reduce to microfilm, every type and size of weather record in its archives.

Less impressive, although sizable, is the volume of duplicated punched cards and reels of magnetic tape sent in answer to requests. The number of tape reels that are duplicated for cus-

tomers (mostly research organizations having computers) is increasing at an accelerating rate, while requests for duplicates of punched cards are becoming less numerous each year. In terms of the total characters of machineable data furnished, the trend is markedly upward.

Data in card decks punched to produce climatological publications are subjected to rigid quality control procedures. However, many of the other card decks in the NWRC contain unedited data. Users of unedited punched card decks or data derived from them often encounter unexpected difficulties in treating these data statistically. Changes in weather reporting practices or curtailment of observational programs may result in missing data or data of undetermined quality. The NWRC, in most cases, encourages customers requesting duplicates of unedited punched cards decks or magnetic tapes to let us perform a quality control job in order that they may be assured of accuracy and completeness of the data. Of course, this is an added expense to the customer, but it usually proves to be a good investment. The application that the customer wishes to make of the data and the particular card deck or magnetic tape family involved are determining factors in whether or not the NWRC recommends quality control.

In addition to reproductions of original records, microfilm, punched cards, and magnetic tapes, the NWRC provides at cost copies of FOSDIC (page 12) and satellite films (made in the dust-free "clean room," figure 15), special data tabulations, radar films, climatological publications out of print, and any other item in the NWRC library.



REQUESTING CLIMATOLOGICAL SERVICES

The variety of users of climatological information is large. They want information for a specific application, information which either is unavailable through published sources, or contained in sources unknown to them. The main differences are the organizations represented, the types of data wanted, the forms in which the data are to be summarized, and the manner in which the jobs are financed. This section provides a discussion on the ways in which various classes of users obtain services of the NWRC, and the importance of users clearly specifying what they want.

IF AN AGENCY OF THE DEPARTMENT OF DEFENSE

Air Force and Army units should forward their requirements for climatological support through military channels to the Director, Environmental Technical Applications Center, USAF, Building 159, Navy Yard Annex, Washington, D.C. 20333. Prior consultation with a local representative of Air Weather Service is advisable whenever possible. Contractors of the Air Force and Army should forward their requirements directly to the Environmental Technical Applications Center through their Contracting Officer.

Navy and Marine Corps units should make their requests for climatological support through appropriate channels to the Director, Naval Weather Service, Navy Department, Washington, D.C. 20390. Work on requests approved by the Director, Naval Weather Service is performed by the National Weather Records Center as specified by the local Navy Representative.

A few military agencies are authorized to obtain climatological services through direct contact with the National Weather Records Center.

IF A NON-MILITARY FEDERAL AGENCY

The National Weather Records Center is authorized by the Economy Act of 1932 to perform work for other Federal agencies. Financing is generally on a reimbursable basis. Non-military Federal agencies make direct contact with the NWRC for services. Work is begun as soon as the necessary arrangements for funding are completed.

IF A NON-FEDERAL AGENCY A PRIVATE ORGANIZATION OR COMPANY, OR AN INDIVIDUAL

In addition to serving the general public through climatological publications, the National Weather Records Center furnishes special services for private clients under the authority of an act of Congress which permits these services at the expense of the requester. The amount the customer is charged in all cases is intended solely to defray the expenses incurred by the government in satisfying his specific requirements to the best of its ability. Regulations require non-Federal clients to make advance payment for special climatological services. Checks or money orders are made payable to Commerce, ESSA, NWRC. The types of financial arrangements follow:

Jobs Estimated to Cost More Than $500.00

The private customer establishes in advance an individual trust fund if the NWRC estimates the cost of his job to exceed

$500.00. Actual costs of the job are charged, including supporting services. Any funds remaining at the conclusion of the job are refunded to the customer.

In some instances our cost estimates are lower than the amount needed to complete a job. Additional funds are requested from the customer as soon as this becomes evident. The customer generally can expect the total cost of his job to be within plus or minus 15 percent of the cost estimate.

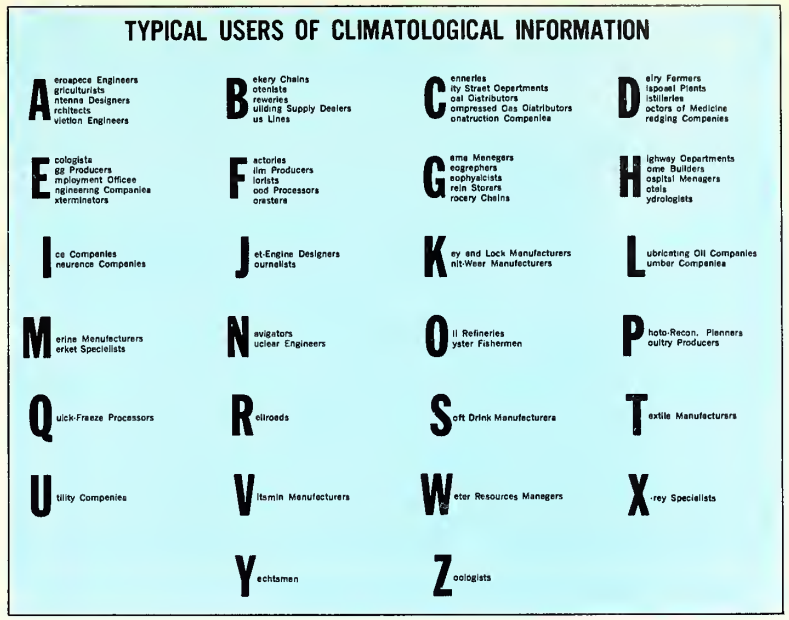
Jobs Estimated to Cost $500.00 Or Less

If the NWRC estimates the cost of a private customer's job to be $500.00 or less, the estimated cost is established as a firm cost. Payment of the estimated cost, therefore, is accepted as payment in full. Regardless of what the job actually costs the NWRC, neither a refund nor a request for additional funds is made to the customer.

Unit costs have been established by the Department of Commerce for reproduction of data in various forms. If your job request is of a type to which unit costs can be applied, the total cost for the service consists of these, plus the cost of personnel services for search and refile.

Open Accounts

Many of our private customers who have continuing need for our services make advance deposits to cover their requirements as they arise. The amount each requester deposits varies with the number and size(s) of the jobs that he anticipates he will require. The deposit may be in any reasonable amount, either less than or more than $500.00, as the customer chooses.



Customers who have continuing requirements for special climatological services find open accounts to be advantageous, because such a funding arrangement permits the NWRC to start on their jobs at once. Thus the delay that is frequently involved in arranging for proper financing is avoided.

JOB REQUESTS AND THEIR SPECIFICATIONS

Three basic categories of job requests are received at the National Weather Records Center. Briefly stated, they are:

1. Those which specifically require copies of basic observational data in various forms (magnetic tape, punched cards, microfilm, original records, etc.).
2. Those which can be satisfied by one or several of the previously published works or unpublished tabulations and summaries in our repository of climatological information.
3. Those dealing with a unique problem which can be satisfied only by a non-routine analysis or through scientific exploration.

It is essential that the customer give us a precise statement of his problem with any type of request he is making. In connec-

REQUESTING CLIMATOLOGICAL SERVICES

tion with requests of the third type, a mutual understanding about the exact specifications of the job may be especially difficult to attain through telephone conversations and correspondence alone. When the customer has a unique and complex problem which involves the application of non-standard climatological summarizations and analyses, it is most advantageous for him to visit the NWRC. In this way, our scientists, data processing specialists, and records specialists can explore the problem with the customer as a team.

When the customer finds a visit to the NWRC impracticable, he may obtain guidance in stating precisely his climatological needs from the following sources:

- Private meteorological consultants
- Weather Bureau Regional and State Climatologists
- Weather Bureau State User Services Representatives
- Personnel in university meteorology departments

Specifications or other information essential to the attainment of pertinent results often are overlooked in requesting climatological services. In making a request, the customer, if at all possible, should include precise information on the following questions:

1. What is the **FINAL USE** to be made **OF** the **PRODUCT(S)** you will obtain from us (if this information is not classified)? The answer to this question enables the climatologist to apply his knowledge and experience concerning the pertience of available data as well as its limitations.
2. What are the **GEOGRAPHICAL AREA(S)** and **PERIOD(S) OF RECORD** of interest?
3. Is information desired on an **ANNUAL** (one composite answer), **SEASONAL** (answers for each portion of the annual cycle), **MONTHLY** (answers for each calendar month), or **OTHER** basis? If seasonal, will the usual Winter (December, January, February), Spring (March, April, May), Summer (June, July, August), and Fall (September, October, November) grouping be suitable, or is some other grouping desired?
4. In what **UNITS** of measurement do you want the values of elements? For example, do you wish wind speeds expressed in miles per hour? meters per second? of knots?
5. Is **DIURNAL VARIATION** (change from one time of day to another) **SIGNIFICANT** for the study? If so, what hours of the day can be grouped? If diurnal variation is unimportant in your study, should we consider all observations available for each day?
6. In what **FORMAT** do you wish the final results? Whenever applicable, the customer should include a rough sketch of the form of presentation he visualizes as a solution to his problem. This simple device usually replaces hundreds of words.
7. How much **TIME** is available to complete your study? The complexity of the study and the workload at the NWRC interrelate to determine the time required to make the product available to you. This may vary from a minimum of a few hours to telephone or TWX the data from a selected few observations, to a few weeks to prepare a "Standard Ceiling-Visibility Wind Rose", to perhaps several months to develop a computer program and process large masses of data in a complex fashion. It is NWRC policy to estimate the time for completion of each requested task when preparing cost estimates.

★ U.S. GOVERNMENT PRINTING OFFICE : 1967 O—242-552

CONCLUSION

We hope the foregoing discussions about our organization, resources, and services have left you with an impression of a public storehouse of climatological information and know-how, staffed with competent public servants eager to serve anyone who needs climatological services. We attempt to furnish the best product possible with the data and techniques available. Final results are always reviewed for meteorological consistency and pertinence to the original request.

You are invited to visit the NWRC for a first hand look at any time.

LIST OF ILLUSTRATIONS

Figure		Page
1.	The Federal Building, Asheville, North Carolina	iii
2.	Research aircraft gathering atmospheric data	iv
3.	A section of the NWRC archives	7
4.	Periods of original records for Washington, D. C.	7
5.	The Climatological Bench-Mark Station Network	8
6.	The network of principal climatological stations	9
7.	The "a" Network in Ohio	10
8.	The Rawinsonde Reporting Network	10
9.	A punch card format of a surface observation	11
10.	A magnetic tape with "seven-level" coding	11
11.	A radar photograph of Hurricane Betsy	13
12.	A tornado-associated radar "hook" echo	13
13.	Western Europe and cloud formations as seen by the NIMBUS I Satellite	14
14.	The NWRC computer complex	16
15.	NWRC's "clean room"	29
16.	Typical users of climatological information	31

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